Original Article

Comparison of modified hand-assisted retroperitoneoscopic laparoscopic nephrectomy and open nephrectomy in patients with benign inflammatory non-functioning kidney diseases

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Background: To assess the validity and feasibility of the modified hand-assisted retroperitoneoscopic laparoscopic nephrectomy (MHARLN) in patients with benign inflammatory non-functioning kidney diseases.

Methods: We retrospectively compared the data of 223 patients who underwent an MHARLN (n=142) or an open nephrectomy (ON) (n=81) with benign inflammatory non-functioning diseases between January 2014 and October 2019 at our hospital. Patients' demographic data, perioperative outcomes, preoperative and postoperative inflammatory data, and postoperative complications were reviewed.

Results: The basic demographic data of patients were similar between the 2 groups. The mean operative times for the MHARLN and the ON were 135 and 143 minutes (P=0.181), respectively. The first time at which postoperative ambulation occurred, the visual analog pain scale (VAS) score before discharge and the postoperative complication rate were similar in both groups. However, compared to the MHARLN, the ON was associated with a more severe inflammatory response on the first day after surgery (P=0.045), higher estimated blood loss (309.8 *vs.* 139.6 mL; P=0.036), more peritoneal ruptures (19.8% *vs.* 9.2%; P=0.024), higher intraoperative transfusion (14.82% *vs.* 4.93%; P=0.011), higher VAS scores 24 hours after surgery (5.9 *vs.* 5.2; P=0.002), additional analgesic use (35.8% *vs.* 21.8%; P=0.024), and longer hospital stays (5.3 *vs.* 4.6 days; P=0.048). Before a liquid diet was commenced in the MHARLN and ON groups, the mean time was 1.2 and 1.5 days, respectively (P=0.004).

Conclusions: When performed by a skilled laparoscopic surgeon, the use of the MHARLN in patients with benign inflammatory non-functioning kidney diseases is reliable and safe. The MHARLN may help to treat challenging cases and result in less trauma successfully.

Keywords: Modified hand-assisted retroperitoneoscopic laparoscopic nephrectomy (MHARLN); open nephrectomy (ON); benign inflammatory non-functioning kidney diseases; challenging cases

Submitted Jan 09, 2021. Accepted for publication Apr 06, 2021.
doi: 10.21037/tau-21-6
View this article at: http://dx.doi.org/10.21037/tau-21-6

Introduction

The laparoscopic nephrectomy (LN) was first introduced in 1991 by Clayman *et al.* (1). Since then, the LN has garnered significant attention, has been developed for use in laparoscopic surgery in urology, and in recent years, has become the most commonly selected treatment for patients who need a nephrectomy. Compared to the open nephrectomy (ON), the LN has significant advantages, including a shorter hospitalization time, the faster recovery

Table 1 Preoperative diagnosis

Variable	MHARLN	ON
Pyonephrosis	59	38
Renal atrophy with stones	7	2
Renal tuberculosis	30	10
Nonfunctional kidney with pyelonephritis	22	12
Inflammatory nonfunctional kidney disease with previous open renal surgery	23	18
XGPN	1	1
Total	142	81

XGPN, xanthogranulomatous pyelonphritis; MHARLN, modified hand assisted retroperitoneoscopic laparoscopic nephrectomy; ON, open nephrectomy.

of bowel movements, decreased analgesic requirements, and a smaller surgical scar (2). However, technical challenges still exist, especially for primary hospital urologists.

Due to the small surgical field and the lack of anatomical landmarks in the retroperitoneoscopic approach, the LN requires a longer learning period for urologists (3). Further, inflammatory renal diseases, such as renal tuberculosis, xanthogranulomatous pyelonephritis (XGPN), a history of previous open renal surgery, and pyonephrosis with heavy inflammation and fibrosis, affect renal adjacent tissues or organs. Thus, a simple LN represents a technically challenging task for community urologists or even experienced surgeons (4). Consequently, open surgery is still necessary to avoid the occurrence of unnecessary iatrogenic injuries. Manohar *et al.* showed that an early transfer surgical procedure might be required in patients with severe inflammatory renal conditions. As open surgery can have longer operative times and be more surgically difficult (5), hand-assisted nephrectomy has emerged over time, especially in the area of LNs for live donors (6-8). One obvious advantage of a hand-assisted nephrectomy includes obtaining tactile feedback via the surgeon's hand. However, hand-assisted devices are expensive and are not available in some developing countries. Thus, we present a modified hand-assisted retroperitoneoscopic laparoscopic nephrectomy (MHARLN) technique, which does not require the use of hand-assisted devices and compares the outcomes of patients with benign inflammatory non-functioning kidney diseases who underwent an MHARLN or an ON from January 2014 to October 2019. The following article is presented following the TREND reporting checklist (available at http://dx.doi.org/10.21037/tau-21-6).

Methods

Patients

From January 2014 to October 2019, a retrospective analysis was performed of 223 patients with similar diagnoses who underwent MHARLN or ON at our medical hospital (see *Table 1*). Patients with high renal and perirenal inflammation levels were evaluated using clinical, laboratory, and radiological parameters. Additionally, a preoperative renal function assessment was performed on all patients before the nephrectomy to confirm that the kidney's diseased side met the resection criteria. Based on a comprehensive evaluation by a surgeon and a patient's admission examination results, a determination was made that it was unlikely that laparoscopy could be used to accomplish the dissection task. Depending on patients' individual characteristics, it is advisable to weigh the benefits and risks of the MHARLN and the ON to discuss the advantages and disadvantages of each procedure and decide with patients which procedure should be performed. A nephrectomy was performed in some patients with pyonephrosis or nonfunctional kidney with pyelonephritis after unsatisfactory treatments of one-stage drainage of percutaneous nephrostomy, ureteral stenting or anti-inflammatory therapy. Patients with renal tuberculosis had to receive 4 weeks of antituberculosis drugs before surgery.

The study was conducted following the Helsinki Declaration (as revised in 2013). The Ethics Committee approved all of the procedures performed in this study of Xiangya Hospital, Central South University (No: 202103041), and informed consent was obtained from all the patients.

Table 2 Demographic data

Variable	Total	MHARLN	ON	P value
Patient (n)	223	142	81	–
Gender (M/F)	89/134	53/89	36/45	0.296
Mean age, years (mean ± SD)	51.2±13.7	50.9±14.3	51.8±12.5	0.613
BMI (mean ± SD)	23.1±2.9	23.1±3.0	23.0±2.7	0.687
Side of lesion (L/R)	108/115	69/73	39/42	0.949
Previous open kidney surgery, n (%)	41 (18.39)	23 (17.0)	18 (22.22)	0.264
Chronic disease, n (%)	36 (16.14)	26 (18.31)	10 (12.35)	0.244
ASA scores (mean ± SD)	1.2±0.4	1.2±0.4	1.2±0.4	0.982
Preoperative anemia (%)	67 (30.04)	40 (28.17)	27 (33.33)	0.419

n, number; M, male; F, female; BMI, body mass index; L, left; R, right; ASA scores, American Society of Anesthesiologists scores; SD, standard deviation.

Operative technique

MHARLN

All operations were performed under general anesthesia, and patients were passively maintained in a full lateral position using a slight table flexion. The surgical procedures are detailed in Appendix 1.

ON

All operations were performed using the 11th or 12th rib flank retroperitoneal approach. The surgical procedure was similar to that described previously (9). Postoperative analgesic was given once in each group, and if more analgesic had to be administered, a note was made that additional analgesics were required.

Statistical analysis

Appropriate tests [e.g., a *t*-test or a chi-square (χ^2) test] were applied to the categorical variables or continuous data. The results are expressed as the number of subjects (n), percentages (%), and mean ± standard deviation. A 2-sided P<0.05 was considered significant. All of the statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) 24.0 (SPSS, Chicago, USA).

Results

Between January 2014 and October 2019, 142 MHARLNs and 81 ONs were performed. During the operations, there was no case in which modified hand-assisted surgery was converted to open surgery.

Concerning age, sex, body mass index, the side of the lesion, a history of open kidney surgery, a chronic disease, including hypertension, type-2 diabetes, coronary heart disease, the American Society of Anesthesiology score, and preoperative anemia (see *Table 2*), the demographic data of the patients were similar across both groups.

Table 3 summarizes the intraoperative parameters according to the surgical approach. Concerning the intraoperative outcomes, the mean operative times of the MHARLN and ON groups were 135 and 143 minutes, respectively (P=0.181). Concerning estimated blood loss, peritoneal rupture, and intraoperative blood transfusion, the differences between the 2 groups were statistically significant. Mean estimated blood loss was higher (309.8 *vs.* 139.6 mL; P=0.036), peritoneal rupture rate was higher (19.8% *vs.* 9.2%; P=0.024), and intraoperative transfusion was higher (14.82% *vs.* 4.93%; P=0.011) in the ON group than the MHARLN group. The pleural injury occurred in 2 patients in the MHARLN group and 1 patient in the ON group, was found intraoperatively and sutured in time without postoperative pneumothorax or other adverse sequelae. There were no significant differences in relation to intraoperative hemodynamics, such as intraoperative blood pressure and heart rate, across all cases.

The preoperative and postoperative inflammatory data are shown in *Table 4*. The white blood cell (WBC) count on the first day after surgery was significantly lower in the MHARLN group than in the ON group (P=0.045). There were no statistically significant differences between the

Table 3 Intraoperative data

Variable	Total	MHARLN	ON	P value
Operative time (mean ± SD, minute)	137.6±43.0	134.7±41.1	142.7±46.0	0.181
EBL (mean ± SD, mL)	201.4±451.5	139.6±157.4	309.8±709.4	0.036
Peritoneal rupture (%)	29 (13.0)	13 (9.2)	16 (19.8)	0.024
Intraoperative blood transfusion (%)	19 (8.52)	7 (4.93)	12 (14.82)	0.011
Pleural injury (%)	3 (1.35)	2 (1.41)	1 (1.23)	0.914

EBL, estimated blood loss.

Table 4 The preoperative and postoperative inflammatory data

Variable	Total	MHARLN	ON	P value
Preoperative WBC count; $\times 10^9$ (mean ± SD)	6.9±2.5	6.7±2.1	7.3±3.1	0.143
Preoperative NEU rate; % (mean ± SD)	63.1±11.3	62.3±10.3	64.5±12.8	0.165
1d-WBC count; $\times 10^9$ (mean ± SD)	11.1±3.6	10.7±3.2	11.8±4.3	0.045
1d-NEU rate; % (mean ± SD)	79.2±11.7	80.1±11.4	77.6±12.2	0.134
WBC count before discharge; $\times 10^9$ (mean ± SD)	8.5±3.1	8.5±3.1	8.6±3.1	0.829
NEU rate before discharge; % (mean ± SD)	73.8±11.3	73.5±10.8	74.5±12.0	0.50

WBC, white blood cell; NEU, neutrophil; 1d-WBC count, white blood cell count on the first day after surgery; 1d-NEU rate, neutrophils rate on the first day after surgery.

2 groups concerning the preoperative WBC count, the neutrophil (NEU) rate, and the first day after surgery NEU (1d-NEU) rate, and the WBC count and NEU rate before discharge. Thus, patients' postoperative inflammatory response in the MHARLN group appeared to be less severe than that of the ON group on the first day after surgery.

The other postoperative data are set out in *Table 5*. There were no significant differences concerning the time of first postoperative ambulation and the visual analog pain scale (VAS) score before discharge between the 2 groups. Compared to patients in the MHARLN group, patients in the ON group had higher VAS scores postoperatively (i.e., 24 hours after surgery; 5.9 *vs.* 5.2; P=0.002), required additional analgesic use (35.8% *vs.* 21.8%; P=0.024), and had longer hospital stays (5.3 *vs.* 4.6 days; P=0.048). The average times before which patients started a liquid diet in the MHARLN and ON groups were 1.2 and 1.5 days, respectively (P=0.004).

Patients' postoperative complications included postoperative fever, wound infection, postoperative bleeding, and postoperative paralytic ileus (see *Table 6*). Postoperative fever occurred in 17 patients (11.97%) in the MHARLN group and 10 patients (12.35%) in the ON group (P=0.934). After anti-infection and symptomatic support treatment, patients' body temperatures returned to normal, and no septic shock occurred. Wound infection was another common complication, resulting in 4.93% of patients in the MHARLN group and 2.47% of patients in the ON group (P=0.369). Three patients in the MHARLN group suffered postoperative bleeding compared to 1 in the ON group. Reoperation was necessary to explore and stop the bleeding in 2 patients in the MHARLN group. The other 2 patients with hemorrhages improved after conservative bedridden treatments and blood transfusions. Postoperative paralytic ileus occurred in 1 patient in the ON group due to dense adhesion and abnormal hilum, which prolonged the length of that patient's hospital stay.

Discussion

Chronic inflammatory non-functioning kidney diseases, such as pyonephrosis, and XGPN, renal tuberculosis, are always accompanied by severe inflammation, dense adhesion, and fibrosis. Severe fibrotic adhesions spread to adjacent tissues and neighboring organs, making surgical separation more difficult and reducing the advantages of

Table 5 Postoperative data

Variable	Total	MHARLN	ON	P value
24h-VAS scores (mean ± SD)	5.4±1.6	5.2±1.5	5.9±1.6	0.002
VAS scores before discharged (mean ± SD)	0.8±0.8	0.7±0.7	0.9±0.9	0.058
Extra analgesic administration (%)	60 (26.9)	31 (21.8)	29 (35.80)	0.024
Time to liquid diet (mean ± SD)	1.3±0.6	1.2±0.5	1.5±0.8	0.004
Time to out of bed (mean ± SD)	1.7±0.9	1.6±0.83	1.8±1.0	0.081
Length of hospitalization (day) (mean ± SD)	4.8±2.1	4.6±1.6	5.3±2.9	0.048

24h-VAS scores, visual analog pain scale scores after postoperative 24 hours.

Table 6 Postoperative complications (according to the Clavien-Dindo's grading system)

Variable	Total	MHARLN	ON	P value
Fever (G II)	27 (11.59%)	17 (11.97%)	10 (12.35%)	0.934
Wound infection (G I)	9 (4.04%)	7 (4.93%)	2 (2.47%)	0.369
Blood transfusion (G II)	2 (0.90%)	1 (0.7%)	1 (1.23%)	0.69
Postoperative bleeding requiring reoperation (G III)	2 (0.90%)	2 (1.4%)	0	0.28
Postoperative paralytic ileus (G II)	1 (0.45%)	0	1 (1.23%)	0.185

G, grade.

laparoscopic procedures (10-12). Some surgeons believe that the ON is a controversial surgical procedure in such circumstances, as the ON has many disadvantages, including large incisions, lengthy postoperative recovery times, and chronic wound pain. The hand-assisted retroperitoneoscopic LN, which was first used in patients with stage T1 renal tumors and living-donor nephrectomies (3,13,14), allows the surgeon to maintain orientation and palpate anatomic landmarks. However, the hand-assisted device is very expensive, is not available in some developing countries, and may not be covered by health insurance, which greatly increases patients' economic burden. Using our experience in retroperitoneal laparoscopic surgery, we made some technical improvements that did not require the use of a commercial hand-assisted device to address these issues. In 2004, we started to implement the MHARLN surgery, mostly in living-donor nephrectomies. As most of the donators were healthy patients with low intraoperative adhesion and fibrosis, the operation was relatively easy to implement (15). As we gained more experience, we became bolder and more innovative and decided to apply this technique to patients with inflammatory non-functioning kidney diseases, for which a simple laparoscopy could not be used. This retrospective study reviewed cases in which the MHARLN was used and compared the results of the MHARLN to those of the ON groups to analyze its surgical feasibility and safety.

Some investigators prefer the transperitoneal approach (5); however, we prefer the retroperitoneal approach. Perihilar and perirenal adhesions are commonly found under inflammatory renal conditions. The retroperitoneal approach enables direct access to the renal hilar, making it easier to control hilum vessels early and reduce bleeding risk, especially in patients with dense adhesions (16). Additionally, as retroperitoneal approaches do not require intraperitoneal manipulation, peritoneal contamination can be avoided, and the mobilization of abdominal organs, intraoperative and postoperative abdominal adhesions, and inadvertent organ injury can be reduced (3,17). In our surgical procedure, we first create as much retroperitoneal space as possible through separation using laparoscopic instruments and then use blunt separation by hand to further increase the surgical space, which minimizes the operational difficulties that arise due to a lack of space. Usually, we use scissors first to separate the avascular area of the kidney, and avoid a blurred visual field of operation by using a harmonic scalpel. Then, under hand guidance, a harmonic scalpel and hem-o-lok clips are

both used to dissect the hilum, and avoid the bleeding of renal vessels during blunt separation under heavy adhesion.

In our study, the intraoperative results showed that the mean operative times and hemodynamics were similar in both the MHARLN and ON groups. However, estimated blood loss, peritoneal rupture and intraoperative blood transfusion, and postoperative inflammation response on the first day after surgery was more common in the ON group than the MHARLN group. Conversely, the postoperative data showed that patients in the MHARLN group had lower VAS scores 24 hours after surgery, required a lower use of additional analgesics, started the liquid diet sooner, and had shorter hospital stays than those in the ON group. In terms of postoperative complications, such as postoperative fever, wound infection, postoperative bleeding, and postoperative paralytic ileus, there were no statistically significant differences between the 2 groups. Han *et al.* reported that wound problems or hernias are common to see in hand-assisted laparoscopic nephrectomies (18). It should also be noted that closing the incision layer by layer to avoid postoperative hernias is necessary, and no hernias were found.

This study showed that the MHARLN is a safe and effective technique for difficult nephrectomies. When bleeding occurs, the gauze placed through the modified hand-assisted incision can be immediately pressed to stop the bleeding (3), which can also be stopped utilizing electrocoagulation or hem-o-lok clips combined with laparoscopic equipment. This prevents the repeated suction of blood via an aspirator that occurs in a standard laparoscopy, which shortens the operation time. Compared to the ON, the MHARLN has the advantages of aesthetics, a fast postoperative gastrointestinal recovery time, lower use of additional analgesics, a shorter hospital stay, and a lower 24-hour VAS score. Further, during an operation, if a massive emergency hemorrhage or the tearing of the viscera occurs, the presence of a hand in the operative field provides tactile feedback, improves the sense of three-dimensional orientation, and provides the surgeon with rapid finger control in complicated situations under the guidance of a laparoscope, and is thus especially suitable for community urologists lacking formal laparoscopy training at primary hospitals (5,19,20). Noguchi *et al.* showed that renal blood flow decreased due to elevated intraabdominal pressure from carbon dioxide pneumoperitoneum. Thus, introducing a hand in an operation might increase mechanical stress and contribute to a decrease in renal blood flow (21,22). In our operations, hand assistance was accurately used. The introduction of a hand increased mechanical stress, which had the benefits of reducing the kidney's blood flow and achieving the effect of hemostasis.

Like all retrospective studies, the present study had some limitations. First, Noguchi *et al.* reported that placing a hand into the relatively narrow retroperitoneal space in the working space forces surgeons to perform a blind, blunt manual dissection with only their tactile senses, makes it difficult to dissect freely and deteriorates the surgical field of vision. Thus, it was thought that blood loss would be increased, and longer operation times would be required (22). In this study, the mean estimated blood loss was significantly higher in the ON group than the MHARLN group, and the differences in the operation times between the 2 groups were not statistically significant. However, such issues still need to be considered. As a confounding factor, the renal hilum position was not recorded and analyzed/controlled, affecting indicators such as the amount of blood loss and operation time. Thus, future details from surgical records need to be examined to address these issues. Second, this retrospective study was only conducted at a single center, and the sample size was small; thus, there was some selection bias in the selection of surgical procedures by surgeons. Finally, in our study, only short-term postoperative complications were examined; however, long-term postoperative complications need to be examined to determine the surgery's surgical efficacy and safety.

Conclusions

The MHARLN can be successfully performed on patients with benign inflammatory non-functioning kidney diseases. Compared to patients who undergo an ON, those who undergo an MHARLN have less estimated blood loss, less need of extra analgesics, more superior cosmetic outcome, and shorter hospital stays. The hand in the operative field also improves the sense of three-dimensional orientation, which shortens the learning time required for a standard retroperitoneal endoscopic nephrectomy. In conclusion, the MHARLN is a safe and reliable surgical option that could successfully treat challenging cases and result in less trauma.

Acknowledgments

Funding: This work was supported by grants from the

National Natural Science Foundation of China (No. 81770693) and the Natural Science Foundation of Hunan province (No. 2020JJ4870).

Footnote

Reporting Checklist: The authors have completed the TREND reporting checklist. Available at http://dx.doi.org/10.21037/tau-21-6

Data Sharing Statement: Available at http://dx.doi.org/10.21037/tau-21-6

Peer Review File: Available at http://dx.doi.org/10.21037/tau-21-6

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/tau-21-6). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Helsinki Declaration (as revised in 2013). All procedures performed in this study were approved by the Ethics Committee of the Xiangya Hospital, Central South University (No: 202103041), and the informed consent of all the patients was obtained.

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Cite this article as: Xia W, Chen X, Liu L, Chen Z, Ru F. Comparison of modified hand-assisted retroperitoneoscopic laparoscopic nephrectomy and open nephrectomy in patients with benign inflammatory non-functioning kidney diseases. Transl Androl Urol 2021;10(5):2027-2034. doi: 10.21037/tau-21-6

MHARLN surgical procedures: This section describes the retroperitoneoscopic approach to building a working channel that uses the 3-port distribution and technique as previously reported by Chen (1). Once a minimally invasive working channel has been established, we first used minimally invasive devices to remove retroperitoneal fat to create a relatively large working space, and then isolated perirenal adhesion tissues as much as possible. Severe fibrotic adhesions are often encountered in these types of patients, and nearly all such dissections are very difficult, even for experienced surgeons. It is unlikely that a pure laparoscopy could accomplish this dissection task. At this stage, the MHARLN was changed to continue the operation.

After closing the pneumoperitoneum, we made a mini-open muscle-splitting incision of approximately 8 cm close to the inguinal canal. The fascia layer was incised lateral to the rectus abdominus, and then dissected using fingers to tunnel from the muscle fibers to the transilluminated retroperitoneum. Confirmation was then obtained that the correct operating space had been entered by the injected gas gushing out (2). Next, the surgeon's hand was inserted into the retroperitoneal cavity through this incision directly without the use of hand-assisted devices. A tight space between the wrist and abdominal wall was formed and the pneumoretroperitoneum was established again. If the incision leaked, tissue forceps or saline gauzes were used to seal the incision. With the help of tactile feedback and laparoscopy, a blunt and sharp dissection were combined to separate the adhesion tissues around the kidney and fully expose the hilar vessels. Hem-o-lok clips were then used to ligate renal hilar vessels, lymphatic vessels, and ureters under laparoscopy. The renal specimen was then removed through the hand-assisted incision without additional injury. If no obvious bleeding was observed in the operative field, a 22-French abdominal drainage tube was placed in the renal fossa, and the modified hand-assisted incision and puncture point were closed by layer sutures.

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http://dx.doi.org/10.21037/tau-21-6